ISSN 2564-3258

RESEARCH ARTICLE

The Role of Vertebral Artery Blood Flow Alteration as a Cause of Vertigo in Cervical Spondylosis: An Observational Study

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Sharma P, Raj KP, Tarafdar S, et al. The Role of Vertebral Artery Blood Flow Alteration as a Cause of Vertigo in Cervical Spondylosis: An Observational Study. Int J Radiol Case Rep. 2025;2(1):09-16.

Abstract

Background: Vertigo is a symptom, not a disease in itself and can be caused by a variety of underlying conditions with diverse origins, including inner ear, brainstem, cerebellum and even internal, vestibular, or psychosomatic factors. Vertigo related to cervical spondylosis often presents with a distinct set of characteristics: it tends to be recurrent, brief in duration, triggered by changes in head position and not typically accompanied by nystagmus (involuntary eye movements). These features can help differentiate it from vertigo caused by other conditions. Our study is first prospective study from Himalayan belt of North India, where we set out to examine whether vertebral artery compression, specifically during neck rotation, plays a role in the development of vertigo in patients diagnosed with cervical spondylosis.

Result: Based on our study, we found that following variables were significantly ($p<0.05$) associated with variable "Vertigo in Spondylosis cases" : right VA diameter (mm) (right rotation position), change in right VA diameter (%) (right rotation position), right VA EDV (right and left rotation position), left VA diameter (mm) (right rotation position), left VA diameter (mm) (left rotation position), change in left VA diameter (%) (left rotation position), left VA PSV (left rotation position), left VA EDV (right and left rotation position).

Conclusion: Our observations suggest a vascular component to dizziness, experienced by patients with CS. In patients with CS and significant osteophyte formation, compression of VA becomes pronounced. Head rotation exacerbates this compression, resulting in vertigo due to Vertebro-Basilar Insufficiency (VBI).

Key Words: *Cervical spondylosis; Degenerative; Colour doppler*

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Received: December 30, 2024, Accepted: February 20, 2025, Published: March 24, 2025

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Introduction

Dizziness and vertigo rank among the most frequent ailments that lead individuals to seek medical assistance. In adults, the lifetime prevalence is about 20%; in elderly persons, it rises to 40%. Vertigo is a symptom, not a disease in itself and can be caused by a variety of underlying conditions with diverse origins including inner ear, brainstem, cerebellum and even internal, vestibular, or psychosomatic factors. Recurrent vertigo has a significant cause that is frequently disregarded: Cervical Spondylosis (CS). Vertigo related to cervical spondylosis often presents with a distinct set of characteristics: it tends to be recurrent, brief in duration, triggered by changes in head position and not typically accompanied by nystagmus (involuntary eye movements). These features can help differentiate it from vertigo caused by other conditions. Our study is first prospective study from Himalayan belt of North India, where we set out to examine whether vertebral artery compression, specifically during neck rotation, plays a role in the development of vertigo in patients diagnosed with cervical spondylosis.

Aim and objective

Our research aims to determine if a causal relationship exists between vertebral artery compression during neck rotation and vertigo in the context of cervical spondylosis. Additionally, we will analyze the impact of degenerative changes associated with cervical spondylosis on vertebral artery blood flow velocity during cervical spine rotation across different head positions.

Material and Method

In this prospective study, 62 patients were enrolled; of these, 31 patients were included in the group titled “cases,” who were between the ages of 30 and 80, had CS that had been clinically and radiologically established and had vertigo symptoms. Group “control” consisted of 31 patients, ages 30 to 80, with radiologically and clinically verified CS and no vertigo symptoms. Cervical Degenerative Index (CDI) was calculated for all 62 patients and both cases and controls had CDI more than 20.

CDI was evaluated based on four factors enlisted in Table 1 (Figure 1). A four-point scale with a range of 0 to 3 was used to assess each of the four factors at each level, which consisted of five levels: C2-C3 to C6-7. Specific quantitative criteria for each factor (except sclerosis) are outlined in Table 1. Summation of component scores across all levels determined the overall CDI, which might have a value between 0 (wholly non-spondylotic appearance) and 60 (highest severe degeneration at each level) [1].

TABLE 1
Cervical Degenerative Index (CDI) factor scoring [1].

Factor	CDI Score			
	0	1	2	3
Disc space narrowing (%)	None–25	25–50	50–75	75–100
Sclerosis	None	Minimal	Moderate	Severe
Osteophytes	None	Small/<2mm	Moderate/2–4mm	Large/>4mm
Listhesis	None	<3 mm	3–5 mm	>5mm

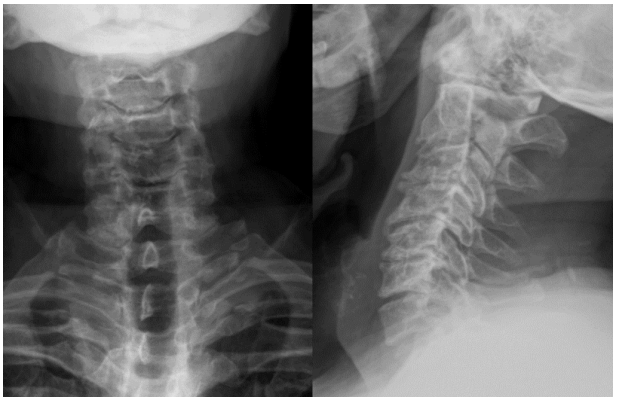

Figure 1) *CS with vertigo CDI score was 26 and patient was included in the study.*

Exclusion criteria:

- People with neck pain who experience vertigo for any other reason that is known.
- Patients with any ear pathology that could be causing their symptoms of vertigo.
- Hypoplastic vertebral artery (difference between diameter of vessel on both side being greater than 1.2 mm).
- Congenital cervical spine anomalies, trauma, previous surgeries, any other inflammatory and infectious conditions affecting the cervical spine.

Patients initially presenting to Orthopaedics department with neck pain with or without dizziness, underwent thorough evaluation, radiographs of cervical spine were obtained and those with CDI >20 were chosen to be part of this study. Those who presented with symptoms of vertigo underwent otolaryngological evaluation to rule out other potential causes of vertigo, such as BPPV, vestibular neuronitis, labyrinthitis and suppurative otitis media.

Using a case record form, demographic information and medical history were gathered. This included information on age, gender, history of hypertension and other comorbidities, trauma history, medications and current symptoms. This all-encompassing method made sure that potential causes of vertigo were looked into and ruled out. Following that, these individuals were referred to the radiodiagnosis department for doppler scan of neck vessels.

Technique

Evaluation of cervical VA was performed using Esoate My Lab 9 ultrasound machine, with 5 to 12 MHz linear array transducer.

USG and doppler protocol [Figure 2-6]

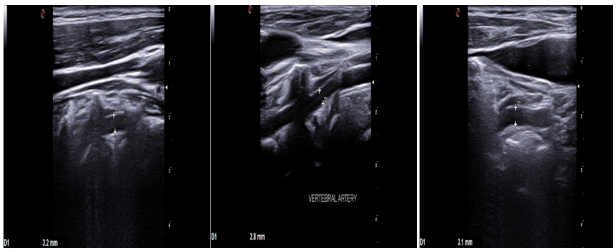

Figure 2) *Diameter of vertebral artery on right side in neutral, right rotation and left rotation position respectively. Reduction in diameter is noted in right rotation position.*

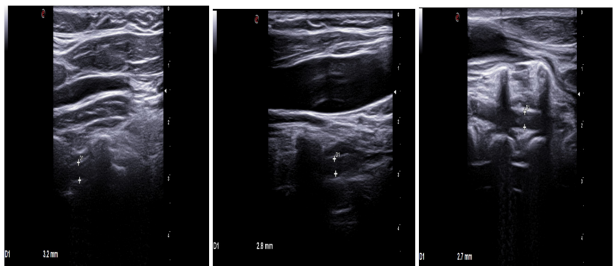

Figure 3) *Diameter of vertebral artery on left side in neutral, right rotation and left rotation position respectively. Reduction in diameter is noted in right and left rotation position.*

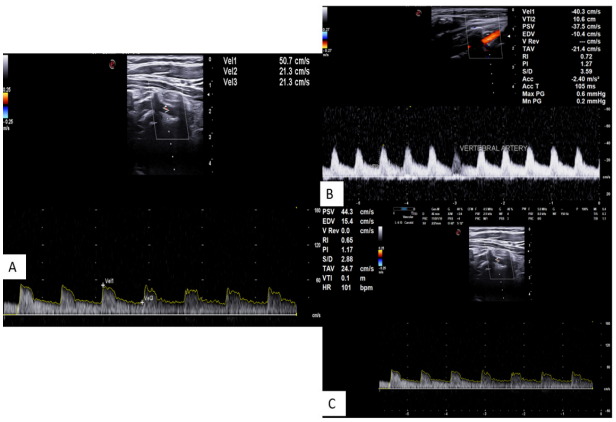

Figure 4) *PSV, EDV of right vertebral artery in neutral (A), right rotation (B) and left rotation (C) position in an individual with cervical spondylosis and vertigo. Reduction in PSV on right rotation and in EDV on right and left rotation positions is noted.*

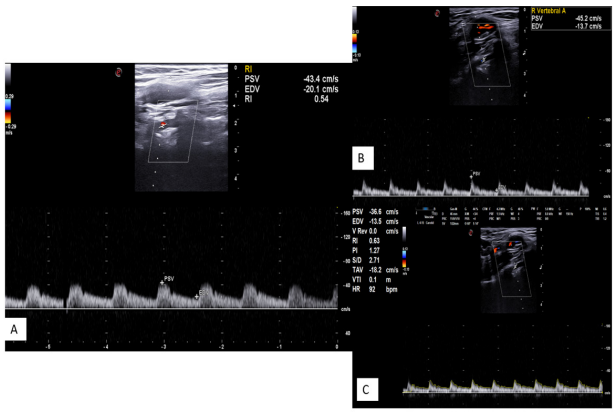

Figure 5) *PSV, EDV of left vertebral artery in neutral (A), right rotation (B) and left rotation (C) position in an individual with cervical spondylosis and vertigo. Reduction in PSV on left rotation and in EDV on right and left rotation positions is noted.*

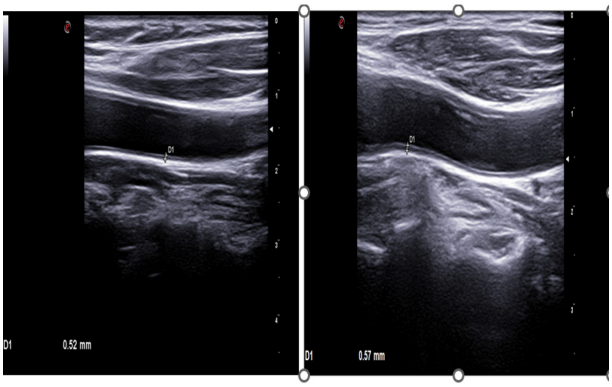

Figure 6) *CIMT of right CCA and left CCA in an individual with cervical spondylosis and vertigo.*

- In order to hyperextend the neck, the patient lied supine with a pillow or rolled towel beneath upper back, between scapula.
- First Scan was performed in neutral position of neck. Each vertebral artery was evaluated individually and various parameters are recorded.
- Scanning was conducted with rotation of neck. The patient turned their neck to the right usually between 60° and 80°, both the vertebral arteries were evaluated and then they are evaluated with neck turned towards left. VA was evaluated at:
- V2 segment, typically at C5–6 intervertebral level.

Segment 2 was identified by its hemodynamic feature, which was characterized by a high diastolic blood flow velocity and by virtue of its location, which was situated medial to the vertebral vein. This was further validated through supplementary spectral analysis. It shows low-resistance pattern with continuous forward diastolic flow, similar to internal carotid artery, as it supplies low-resistance posterior circulation. Peak Systolic Velocities (PSV) for VA waveforms typically ranged from 20 to 60 cm/s, with a strong systolic upstroke and a well-defined systolic peak.

In all 62 of the patients in this investigation, we assessed the blood flow velocity through the VA during cervical rotation and investigated the possibility of a correlation between vertigo and reduced blood flow velocity through the VA during head rotation. We also examined the thickness of the carotid intima-media on both sides.

Observation and Result

62 patients were a part of this study, done over a span of 18 months, with 31 patients in group "cases" (with symptom of vertigo) and 32 patients in group "control" (without symptom of vertigo). Mean age was 49.77 years $\pm$ 8.91 Standard Deviation (SD) in cases group and 50.97 years $\pm$ 5.81 Standard Deviation (SD) in control group Table 2. The age group of 50–59 years old had the highest number of patients, followed by 40–49 years old. In both groups, there were more males, as compared to females.

People with vertigo had smaller right VA diameters in neutral, right and left rotation positions than people without vertigo, although the difference was only statistically significant in the right rotation position. Whereas in comparison to controls, cases had a smaller left VA diameter in all three positions (neutral, right rotation and left rotation position). For both right and left rotation positions, this difference was statistically significant ($P<0.05$).

TABLE 2
Showing relationship between various parameters and vertigo in spondylosis cases [2].

Parameters	Vertigo in spondylosis cases		p value
	Present (n = 31)	Absent (n = 31)	
Age (Years)	49.77 ± 8.91	50.97 ± 5.81	0.535[1]
Age Range			0.470[2]
30-39 Years	4 (12.9%)	1 (3.2%)	
40-49 Years	8 (25.8%)	12 (38.7%)	
50-59 Years	17 (54.8%)	17 (54.8%)	
60-69 Years	2 (6.5%)	1 (3.2%)	
Gender			0.442[3]
Male	19 (61.3%)	16 (51.6%)	
Female	12 (38.7%)	15 (48.4%)	
RVA: Diameter (mm) (Neutral position)	3.41 ± 0.25	3.46 ± 0.14	0.295[4]
RVA: Diameter (mm) (Right Rotation position) ***	3.31 ± 0.25	3.47 ± 0.17	0.011[4]
Change in RVA: Diameter (mm) (Right Rotation) ***	-0.10 ± 0.11	0.01 ± 0.13	0.003[4]
Percent Change in RVA: Diameter (mm) (Right Rotation) ***	-2.80 ± 3.41	0.31 ± 3.78	0.003[4]
RVA: Diameter (mm) (Left Rotation position)	3.29 ± 0.24	3.40 ± 0.18	0.065[4]
Change in RVA: Diameter (mm) (Left Rotation)	-0.12 ± 0.14	-0.06 ± 0.17	0.278[4]
Percent Change in RVA: Diameter (mm) (Left Rotation)	-3.31 ± 4.16	-1.70 ± 4.92	0.211[4]
RVA: EDV (Neutral position)	19.01 ± 4.15	18.89 ± 4.25	0.914[1]
RVA: PSV (Right Rotation position)	43.26 ± 7.07	43.56 ± 5.83	0.688[4]
RVA: EDV (Right Rotation position) ***	14.86 ± 3.33	18.09 ± 4.58	0.002[1]
RVA: PSV (Left Rotation position)	41.46 ± 6.35	42.70 ± 6.88	0.349[4]
RVA: EDV (Left Rotation position) ***	13.94 ± 3.05	17.24 ± 4.16	0.002[4]
LVA: Diameter (mm) (Neutral position)	3.40 ± 0.21	3.49 ± 0.15	0.087[4]
LVA: Diameter (mm) (Right Rotation position) ***	3.29 ± 0.22	3.43 ± 0.17	0.011[4]
Change in LVA: Diameter (mm) (Right Rotation)	-0.11 ± 0.12	-0.06 ± 0.11	0.156[4]
Percent Change in LVA: Diameter (mm) (Right Rotation)	-3.19 ± 3.78	-1.75 ± 3.10	0.131[4]
LVA: Diameter (mm) (Left Rotation) ***	3.26 ± 0.21	3.43 ± 0.16	0.002[4]
Change in LVA: Diameter (mm) (Left Rotation) ***	-0.14 ± 0.10	-0.05 ± 0.13	0.005[4]
Percent Change in LVA: Diameter (mm) (Left Rotation) ***	-4.05 ± 2.82	-1.52 ± 3.63	0.001[4]
LVA: PSV (Right Rotation position)	41.05 ± 5.05	43.12 ± 3.38	0.065[1]
LVA: EDV (Right Rotation position) ***	14.16 ± 3.98	18.75 ± 3.54	<0.001[1]
LVA: PSV (Left Rotation position) ***	38.33 ± 3.89	42.00 ± 4.19	0.001[1]
LVA: EDV (Left Rotation position) ***	13.30 ± 2.65	17.60 ± 3.48	<0.001[1]
RCCA IMT (mm)	0.58 ± 0.04	0.58 ± 0.04	0.832[4]
LCCA IMT (mm)	0.58 ± 0.04	0.56 ± 0.06	0.805[4]

***Significant at p<0.05, 1: t-test, 2: Fisher's Exact Test, 3: Chi-Squared Test, 4: Wilcoxon-Mann-Whitney U Test

Blood flow velocity (EDV) in the right VA was statistically significantly lower in vertigo sufferers than in non-vertigo sufferers in both the right and left rotation positions; however, the difference in PSV was not significant in any of the three positions.

With the exception of PSV in the right rotation position, the blood flow velocity in the left VA was statistically significantly lower in vertigo sufferers than in non-vertigo sufferers for both the right (EDV) and left (PSV, EDV) rotation positions.

There was no statistically significant difference in mean intimal thickness of CCA between two groups.

Trends Table 2

- Best parameter in terms of area under ROC curve: Left VA EDV (left rotation position).
- Best parameter in terms of sensitivity: Left CIMT (mm).
- Best parameter in terms of specificity: Left VA PSV (neutral position).
- Best parameter in terms of positive predictive value: Left VA EDV (left rotation position), Left VA PSV (neutral position).
- Best parameter in terms of negative predictive value: Left CIMT (mm).
- Best parameter in terms of diagnostic accuracy: Left VA EDV (left rotation position), Left VA EDV (right rotation position).

Discussion

There is not much research on the phenomenon of CS causing vertigo. The vertebro-basilar circulation supplies the vestibular labyrinth, vestibulocochlear nerve, brainstem, cerebellum and occipital lobes. When the head rotates to either side, cervical osteophytes can obstruct the VA, resulting in vert ebro-basilar insufficiency. Vertigo is the most common complaint among VBI patients.

Our study was a prospective observational study done in Himalayan belt of North India, with inclusion of 62 patients. Based on our study, we found that following variables were significantly ($p<0.05$) associated with variable "Vertigo in Spondylosis cases" : right VA diameter (mm) (right rotation position), change in right VA diameter (%) (right rotation position), right VA EDV (right and left rotation position), left VA diameter (mm) (right rotation position), left VA diameter (mm) (left rotation position), change in left VA diameter (%) (left rotation position), left VA PSV (left rotation position), left VA EDV (right and left rotation position).

These results indicate that individuals with vertigo in context of CS, exhibit significantly greater reduction in right VA diameter during right rotation and in left VA diameter during left rotation, as compared to individuals without vertigo in context of CS. This could potentially be linked to compromised blood flow, or increased mechanical compression during head rotation, which might contribute to the vertigo symptoms. In contrast, those without vertigo appear to have a more stable VA diameter, which could imply a lesser degree of vascular compromise, or mechanical distortion during rotation.

Our study aligns with and expands upon previous published studies in several ways. For instance, study by [2,3] concluded that patients with CS exhibited VA compression during neck rotation, which was associated with dizziness and imbalance. Our findings corroborate this, showing that VA narrowing is significant on neck rotation in CS in patients with vertigo. Lacunae in these previously published studies was that these studies had small sample size and contribution of other unknown factors contributing to symptoms of vertigo couldn't be ruled out.

Our study adds to the previous studies as it included additional variables, such as change and percentage change in diameter for right and left rotation in individual patients, as well as change and percentage change in diameter for rotation in both cohorts. Significant association was observed in the cohort "Vertigo in Spondylosis cases": change in right VA diameter (%) (right rotation position) and change in left VA diameter (%) (left rotation position).

In contrast, some studies have questioned the direct association between CS and VA compromise [4] did a study in 2021 and concluded that despite high prevalence of vertigo among degenerative cervical myelopathy patients, the ethology in patients could be traced to factors unrelated to cervical spine and associated nerve structures like haemodynamically significant stenosis of internal carotid artery, uncontrolled hypertension, orthostatic dizziness, BPPV. They concluded that their findings supported the notion that CV was over diagnosed in patients with vertigo.

Our findings add to this discourse by highlighting those significant changes in VA diameter, rather than flow velocity alone, might be critical in understanding vascular contribution to vertigo, in these patients.

Clinical implications

The clinical implications of our study are significant. The finding of reduced VA diameter suggests that patients with CS and vertigo, may benefit from detailed vascular assessment. Doppler sonography, as used in our study, could be a valuable diagnostic tool in identifying patients at risk of vascular compromise. This tool's ability to detect significant arterial narrowing, could lead to more targeted therapeutic interventions, such as physical therapy (to improve neck mobility and to reduce vascular compression) or surgical options.

Moreover, our study emphasizes the need for a comprehensive diagnostic approach in patients presenting with vertigo and CS. While vascular compromise is a critical factor, other potential etiologies, including neurological and otorhinolaryngological conditions, must be considered to avoid misdiagnosis and to ensure appropriate treatment [5,6].

Limitations and future research direction

Our study has several limitations, some of which include the following:

- Our study had small sample size. For a more exhaustive analysis, a broader, multifaceted study encompassing multiple centres is imperative.
- This study was limited to a single tertiary healthcare facility in India, its findings might not apply to patients in other regions.
- USG is commonly employed to assess blood flow in VA due to its reliability, real-time imaging capability and cost-effectiveness. However, its utility is constrained by user proficiency, limited angles for insonation and the unidirectional encoding of velocity.
- When applied to VA, USG encounters additional hurdles. About 7% of these arteries cannot be adequately imaged due to their depth and bone obstructs USG waves, hindering visualization of segments passing through osseous foramina. Moreover, surface-based USG exhibits lower resolution, as compared to other imaging modalities, limiting the detection of subtle anatomical abnormalities.
- Angle invariant measure such as resistive index would have given more accurate results as velocity measurements would differ with change in doppler angle.

In patients with severe CS, vertigo and dizziness are rather common, but it's important to rigorously assess the diagnosis of CV and

look into other (often curable) explanations. This approach helps ensure that other systemic issues are not overlooked.

Future research should focus on substantiating these findings on larger, more diverse population, spanning over wide geographical region. We should also try to explore the integration of imaging techniques, such as advanced MRI or CT angiography, to complement Doppler USG. These methods can provide a more detailed understanding of anatomical and hemodynamic changes in VA and thereby help to further refine diagnostic and therapeutic strategies. Additionally, longitudinal studies could assess the predictive value of Doppler findings over time and investigate the potential benefits of early vascular assessment, in preventing or mitigating vertigo symptoms, particularly in patients with CS.

Conclusion

Our observations suggest a vascular component to dizziness experienced by patients with CS. In patients with CS and significant osteophyte formation, compression of VA becomes pronounced. Head rotation exacerbates this compression, resulting in vertigo due to VBI. However, there could be other unknown causes and factors which could contribute to patients' symptoms of vertigo. To substantiate this association, further research encompassing a larger and multicentric study population is warranted.

The prospective role of VA Doppler as a routine screening tool for predicting vertigo in individuals with CS, holds considerable promise.

Abbreviations

CS: Cervical Spondylosis

BPPV: Benign Positional Paroxysmal Vertigo

CT: Computed Tomography

CDI: Cervical Degenerative Index

CIMT: Carotid Intima-Media Thickness

CV: Cervical Vertigo

DISH: Diffuse Idiopathic Skeletal Hyperostosis

EDV: End Diastolic Volume

MRI: Magnetic Resonance Imaging

OPLL: Ossification of Posterior Longitudinal Ligament

PSV: Peak Systolic Velocity

USG: Ultrasound

VA: Vertebral Artery

VBI: Vertebro-Basilar Insufficiency

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